Time-Series and Applications of Advanced Sentinel-1 Analysis Ready Data for Africa (SAR-4-Africa)

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NORCE - Norwegian Research Centre AS

VH-RODA and CEOS WGCV SAR 2019 Workshop, ESA ESRIN, Frascati, 18-22 November 2019
Overall Goal: Support Earth Observation for the 2030 Agenda of Sustainable Development with Synthetic Aperture Radar (SAR)

EU Copernicus Program – Sentinel-1

- SAR Game Changer in 2014
- From research to fully operational set-up
- Worldwide consistent dense time series of cloud and sunlight independent radar imagery.
- Many still unexploited monitoring applications in general and especially in persistently cloud-covered areas.
SAR Imagery Challenges

Strong reluctance by a large user community to use SAR data because of its:

- **unfamiliar appearance** compared to optical data for untrained users
- **complexity** in regard to sensor-specific noise (speckle), topographic effects,
- **(pre-) processing requirements,**
- **vast amount of data**

**Solution:** Provide easy-to-use Advanced SAR Analysis Ready Data

- Monthly & yearly averaged mosaics as RGB backscatter images (VV, VH, NDI)
- Yearly statistical parameters (variance, max, min, median, nr of acquisitions),
  → Visually attractive, ease visual interpretation, reduce amount of data
Focus on African Users

Demonstration Sites in 5 countries
(2°x 2° latlon, 12000x12000 pixels, 20m)
1. DRC (OSFAC)
2. Ethiopia (ESSTI)
3. Ghana
4. Malawi
5. South Africa

User driven approach through user assessment and feedback
Ghana

- Whole country (239,460 km$^2$) has been processed for the African Regional Data Cube (~1TB / year)

- Dividing Ghana into 5x7 tiles of about 1$^\circ$ lat x 1$^\circ$lon (5200x5200 pixels).

- Pre-processing all S1 data into $\gamma^\circ$: georeferencing, radiometric calibration, terrain & slope correction

- Averaging into monthly and yearly mosaics RGB = [VV, VH, NDI=(VV-VH)/(VV+VH)]

- Yearly statistical analysis for each polarization VV and VH (6 bands): Mean, variance, nr_of_acquisitions, minimum, maximum, mask for SAR shadow and overlay.

→ 13 Mosaics/year (3 bands)
→ 2 Statistic files/year (6 bands)
→ 175 GB / year (can be reduced)
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Illegal Mining (Galamsey) detection with monthly time series of 2018
Galamsey detected with Sentinel-1 (2015-2018) comparing yearly mosaics

Validation polygones from VHR data

<table>
<thead>
<tr>
<th>Period</th>
<th>Forest loss</th>
<th>Area loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-2015:</td>
<td>4.00%</td>
<td>12.44 km² → 0.6 soccer field/day</td>
</tr>
<tr>
<td>2015-2016:</td>
<td>1.41%</td>
<td>4.38 km² → 1.7 soccer field/day</td>
</tr>
<tr>
<td>2016-2017:</td>
<td>2.04%</td>
<td>6.34 km² → 2.4 soccer field/day</td>
</tr>
<tr>
<td>2017-2018:</td>
<td>2.91%</td>
<td>9.05 km² → 3.5 soccer field/day</td>
</tr>
</tbody>
</table>
Malawi

Applications

• Agriculture
• Flooding

RGB = [γ_{VV}; γ_{VH}; NDI]
Flood mapping after cyclone Idai in Mozambique/Malawi (March 2019): (a & b) RGB = [$\gamma_{VH}$; $\gamma_{VV}$; NDI],
(c) Detected flooded areas in red. Contains modified Copernicus Sentinel-1 data (2019).
South Africa

Application
- Savannah biomass estimation
South Africa

Biomass vs Backscatter (2017-08)

-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4

Backscatter (dB)

Above Ground Biomass (t/ha)

VH Backscatter

Biomass

AGB

0

95

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User Feedback

• Was collected about 1-2 month after delivery using a Service Assessment Sheet.
• Not enough time to give a thorough feedback.
• Did not come up with a alternative ASARD definition
But:
• Users are very satisfied and reported better speckle noise reduction and terrain correction than what they are used to from own processing.
• Reduced their total amount of data download
• Would like to have this country-wide and for the whole Sentinel-1 period.
Conclusion

• SAR averaged mosaics and statistical parameters serve well as Analysis Ready Data → User satisfaction.

• Monthly and yearly time-series are easy to combine and analyze and help to reveal areas with strong dynamics.

• Many potential applications:
  • Forest Monitoring
  • Agricultural Monitoring
  • Illegal Mining Monitoring
  • Disaster monitoring like flooding
  • Etc.

• Transfer processing into the cloud and implementation in data cubes, i.e.
  • the African Regional Data Cube: [http://52.54.26.108](http://52.54.26.108)
  • Ghana Sentinel 1 Change Detection: [http://tinyurl.com/ardcs1demo](http://tinyurl.com/ardcs1demo)
Thank you for your attention.

Acknowledgements

H. Hindberg, T. Grydeland, Y. Larsen (Norut) \(\rightarrow\) processing tools

Satellite Data has been provided by

![ESA Logo](esa.png)

![Copernicusus Logo](copernicusus.png)

Funded by

- NASA Langley Research Center contract No.: NNL16AA05C
- ESA EO Science for Society program contract No.: 4000125675/18/I-NB